Tailoring exchange bias coupling in Au/Co/Ni systems by plasma oxidation

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The exchange bias (EB) coupling has been intensively studied for many years in ferromagnet(FM)/antiferromagnet(AFM) thin film systems with perpendicular magnetic anisotropy (PMA). This significant attention is because of their potential use in many applications (e.g. magnetic random access memories, hard drive read heads, etc.) [1]. Nowadays, a new aspect of this interaction is broadly investigated, namely the role of this interaction in PMA enhancement. It has been shown in several systems (e.g. Fe/Mn [2], $(Ni_{80}Fe_{20})/Mn$ [2], Co/NiO [3]) that coupling between the FM and the AFM is an additional source of PMA for the FM films.

Here, we investigate how plasma oxidation (PO) influences the PMA and the EB coupling of Ti/Au/Co/Ni layered systems. After deposition, the sample was treated with oxygen plasma to oxidize the Ni layer. Our previous research indicates that this process leads to the formation of NiO on top of the Co/Ni system. As a result, a significant increase in the coercive field (H_c) is observed, which could be attributed to EB coupling. To verify this, we performed field cooling (FC) process in a perpendicular magnetic field ($H_\perp$) to induce the unidirectional anisotropy of the Co/Ni system. Measurements were carried out in high vacuum by using a liquid nitrogen cryostat. The samples were cooled down to $T = 78K$ at $H_\perp = 3kOe$. At this temperature, we found a shift of the hysteresis loop along the field axis (H_{EB}), which evidences EB coupling between the oxidized Ni and the Co/Ni bilayer. The FC process was repeated three times for an oppositely directed H to confirm that the shift direction is due to the EB coupling. Since the H_c and H_{EB} values depend on the AFM thickness, we deposited an additional NiO layer on top of the oxidized Ni layer. At low temperatures, we found higher values of H_c and H_{EB} than those of the sample with thinner NiO layer. Moreover, the H_{EB} is preserved even at RT which was not a case for samples without additional NiO layer. We also found that the effective anisotropy for such a system is strongly enhanced, which means that formation of a Ni/NiO interface by plasma oxidation constitutes a novel tool to tune EB coupling and magnetic anisotropy of thin Co (or ferromagnetic) films.

References:

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